

## ATTORNEY DOCKET NUMBER M70660

## BINDERS FOR FIELD EMISSION DISPLAYS

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This invention was made with Government support under Contract No.  
5 DABT63-93-C-0025, awarded by the Advanced Research Projects Agency (ARPA).  
The Government has certain rights in this invention.

## BACKGROUND OF THE INVENTION

The present invention generally relates to an improvement in the binding  
10 of phosphors to the display screen of field emission displays and, in particular, to the  
use of inorganic and organic binder materials which may be either conductive or  
semi-conductive.

Summary Field emission display (FED) technology utilizes a matrix addressable  
array of pointed, thin film, cold field emission cathodes in combination with a  
15 phosphor luminescent screen, as represented for example by U. S. Patent No.  
5,210,472, the disclosure of which is incorporated herein by reference. An emissive  
flat panel display operates on the principles of cathodoluminescent phosphors excited  
by cold cathode field emission electrons. A faceplate having a cathodoluminescent  
phosphor coating, similar to that of a cathode ray tube, receives patterned electron  
20 bombardment from an opposing baseplate thereby providing a light image which can  
be seen by a viewer. The faceplate is separated from the base plate by a narrow

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*Summary* vacuum gap. Arrays of electron emission sites (emitters) are typically sharp cones on the cathode that produce electron emission in the presence of an intense electric field. A positive voltage is applied to an extraction grid, relative to the sharp emitters, to provide the intense electric field required for generating cold cathode electron emission.

FEDs are less tolerant to particle shedding from the faceplate than CRTs, and thus excellent and repeatable adhesion and faceplate integrity are required. The cathode of the field emission display is in very close proximity to the faceplate and is sensitive to any electronegative chemicals arriving on the cold cathode emitter surfaces, which could absorb them and increase the value of the emitter work function. Typically FEDs are operated at anode voltages well below those of conventional CRTs. The material properties of the surface, distance along the surface, and changes in the orientation of the surface relative to a straight line between the two voltage nodes determine the voltage at which flashover between the cathode and faceplate occurs. Because FEDs employ lower anode voltages, phosphor material screening and the process of binding them to each other and to the faceplate have to be optimized and tightly controlled to minimize the dead layer and allow for effective excitation of the phosphor. Most phosphor lifetimes are largely determined by the total accumulated charge delivered per unit area through the life of the display.

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## SUMMARY OF THE INVENTION

The present invention relates to the use of binders, both inorganic and organic, for providing sufficient binding action to hold powder phosphor particles together as well as on the glass screen of a field emission display. The binder materials can be either conductive or semi-conductive in nature.

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## DETAILED DESCRIPTION OF AN ILLUSTRATIVE EMBODIMENT

Field emission displays emit visible light following excitation of a phosphor screen via electrons from a cold cathode based on either silicon (Si), molybdenum (Mo), tungsten (W), etc. microtips. As the phosphor coated screen is in very close proximity with the microtips, any particles which come loose from the phosphor screen could cause fatal damage to the tips or shorting. As such, the present invention proposes to the use of binders, both inorganic and organic, for providing sufficient binding action to hold the powder phosphor particles together as well as on the glass screen. Furthermore as the phosphor screen of a field emission display is not normally aluminized, as are most cathode ray tubes, there is a possibility of space charge build up which could lead to a decreased luminescent efficiency. Thus the present invention further proposes that the binder materials used be of a conductive or a semi-conductive nature to eliminate this problem.

Preferably the binder, according to the present invention, is polyvinyl alcohol, potassium silicate, ammonium silicate, or it may be such that heating the

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phosphor/binder screen yields a conductive binder, e.g., tin(II) 2-ethylhexanoate, tin (IV) isopropoxide, tin (II) oxalate, titanium (IV) ethoxide, zinc 2,4-pentane dionate, zinc acetate, zinc oxalate. Suitable binder materials include poly(propylene carbonate), poly(propylene carbonate) and poly(ethylene Carbonate) sold by PAC Polymers Inc. of Greenville, DE as QPAC-40 Emulsion, QPAC-40 and QPAC-25, respectively.

For these compounds a simple heating process removes the organics and leaves behind a conducting or semiconducting oxide which binds the phosphor particles to each other and to the glass screen. The glass screen is normally coated with transparent conducting film such as indium tin oxide (ITO), zinc oxide (ZnO), tin oxide (SnO<sub>2</sub>) with antimony (Sb) doping, cadmium oxide (CdO), cadmium tin oxide Cd<sub>2</sub>SnO<sub>4</sub> (cadmium stannate) etc.

In general these organometallic compounds would be from the following group: cadmium (Cd), titanium (Ti), zinc (Zn), tin (Sn), indium (In), antimony (Sb), tungsten (W), niobium (Nb), etc. which would form conductive and semiconductive oxides when heated. In addition, these oxides are preferably transparent.

Three phosphors (green, red, blue) are applied to the faceplate in separate (wet application i.e., as a slurry or electrophoresis or dry application i.e., as a powder on a wetted faceplate) operations. The phosphor particles range in size from 1 to 5  $\mu$ m in diameter and are coated to a thickness of 1-10  $\mu$ m, or 1-3 particles deep. The subject binders are applied with or after the phosphors in a similar wet operation.

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The preferred method for applying these binders is by spray coating, or by adding to the phosphor material during its deposition.

In another embodiment, the anode may be patterned with a mask, such as photoresist, to prevent accumulation of the conductive binder in unwanted areas, such as between conductive traces.

The binding material is heat treated to temperatures in the range of to 20°C to 600°C for a period of from 2 to 200 minutes under pressures of from 760 to  $10^{-6}$  Torr in an atmosphere of air or somewhat reducing atmosphere, depending on the type of binder.

The present invention may be subject to many modifications and changes without departing from the spirit or essential, characteristics thereof. The present embodiment should therefor be considered in all respects as being illustrative and not restrictive of the scope of the invention as defined by the appended claims.

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